The Complexity of Soil Landscapes: Variability from the macro-scale to the micro-scale

Angela Bedard-Haughn
Department of Soil Science

University of Saskatchewan
College of Agriculture and Bioresources

www.agbio.usask.ca

Joe Ellis' soil-forming factors

Factors which Determine Soil Type:

The factors that determine soil type (or group) are:

(1) The climate, or the temperature and moisture within the soil;

(2) The vegetation, which determines the type of organic matter added to the soil;

(3) The parent material, or the geological deposits which determine the minerals on which the soil is formed, and in turn affect the texture, the water retention capacity, and the mineral reserve;

(4) The position in which the soil is found in relationship to the topography;

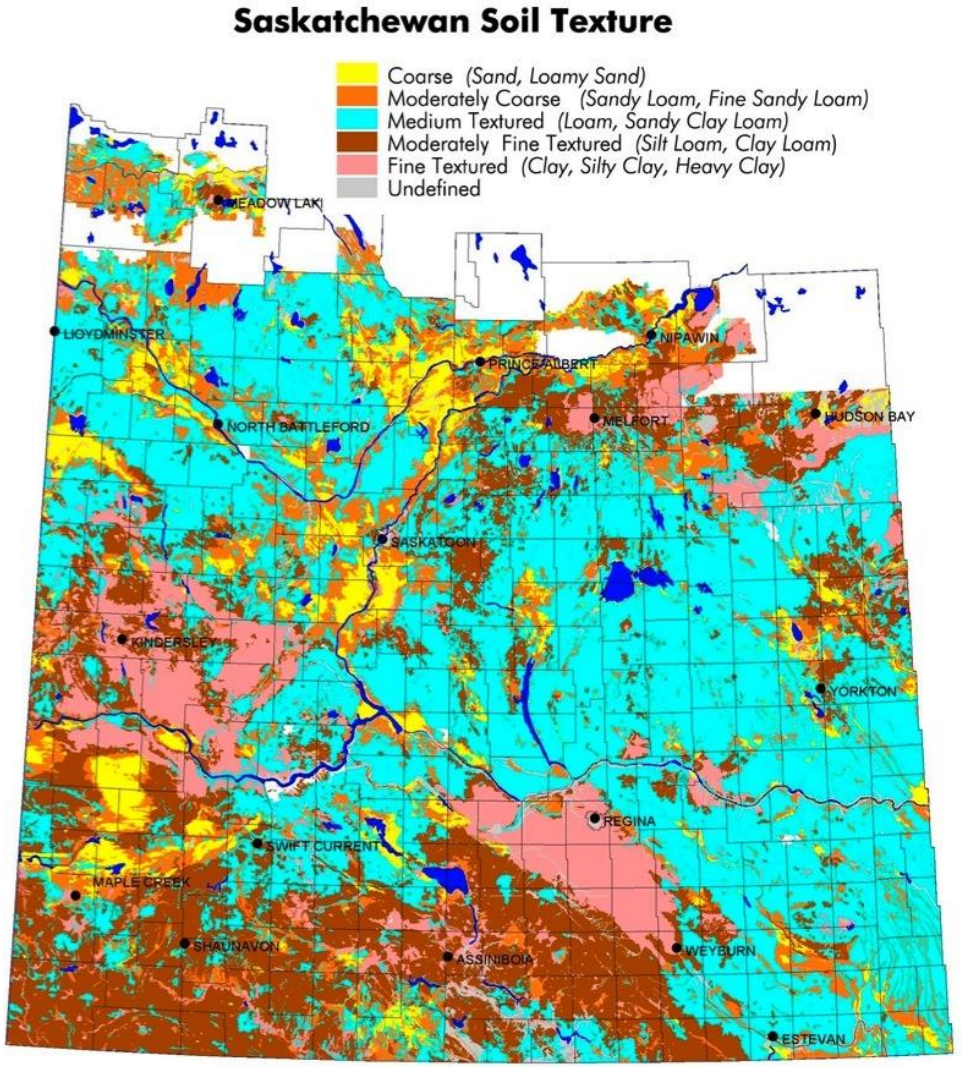
(5) The presence or absence of ground water within the soil profile;

(6) The age or length of time the soil has been under the influence of its environment; and

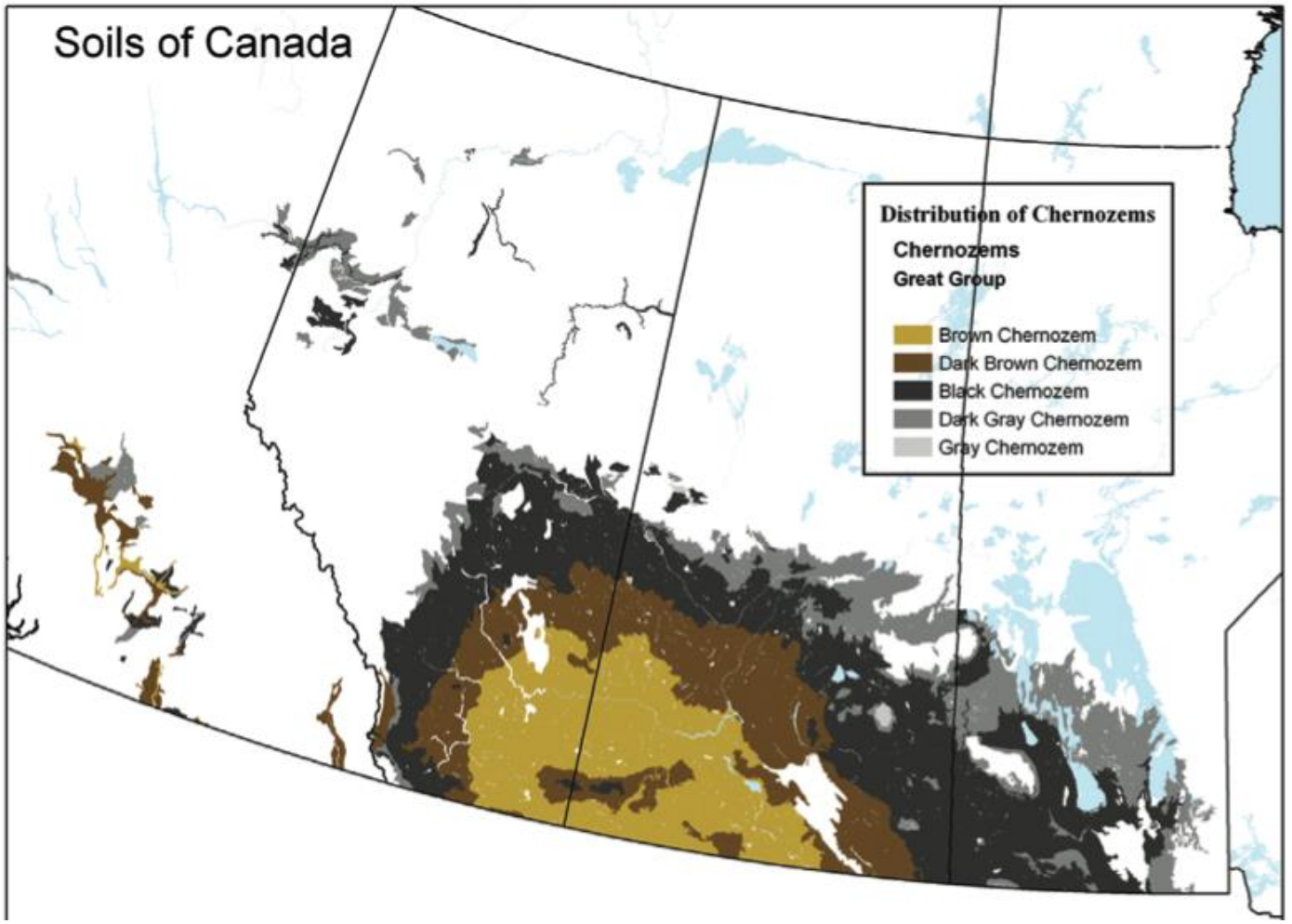
(7) In the case of cultivated soils—the modifying effects of culture or the work of man.

Ellis 1938 Soils of Manitoba

Macro-scale: Parent material

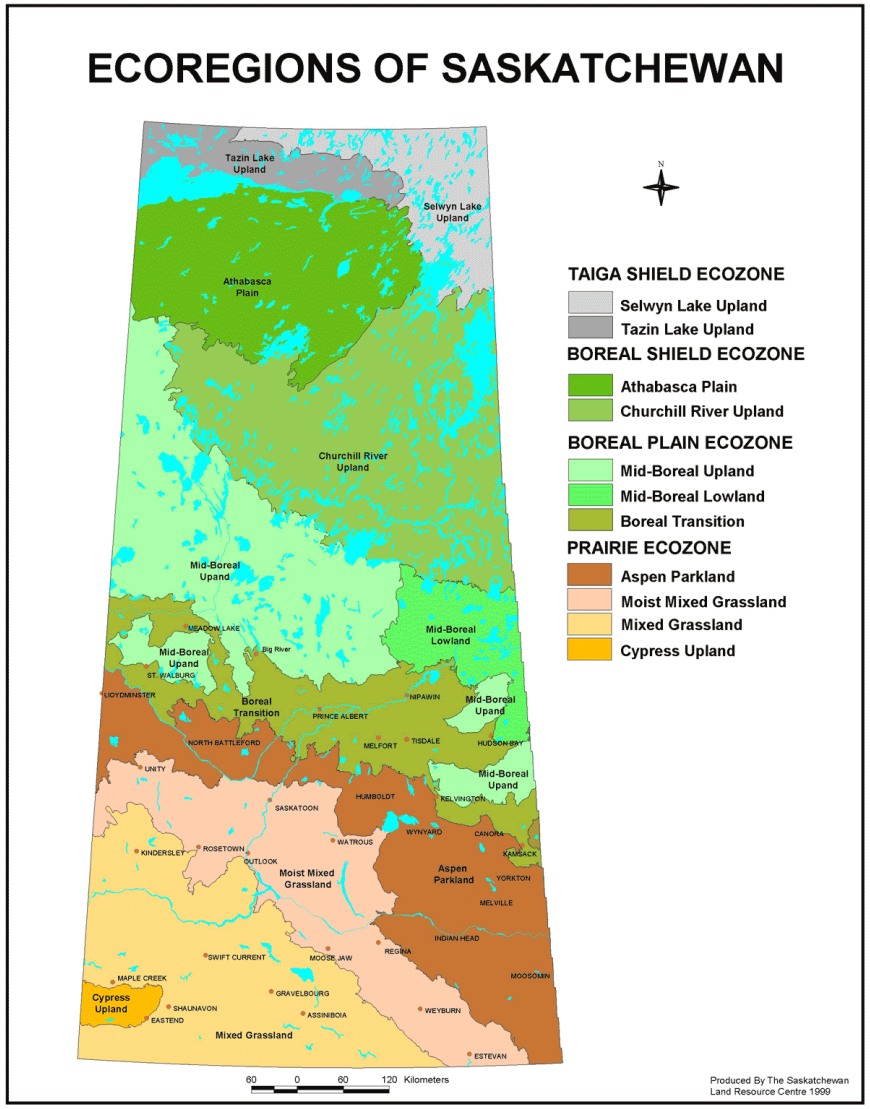


Macro-scale: Climate

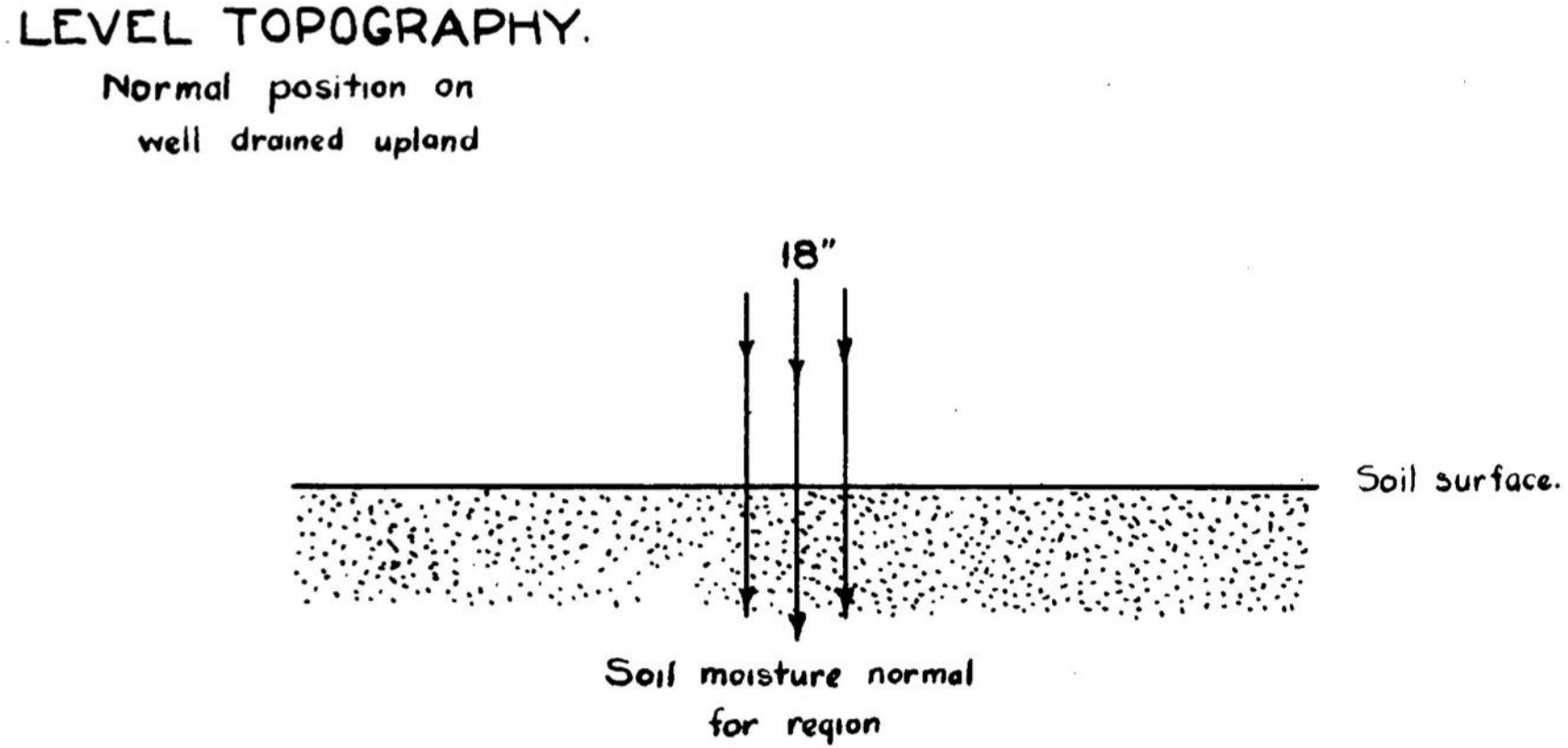


Pennock et al. 2011 CJSS 91: 719-747

Macro- to Micro-scale: Organisms

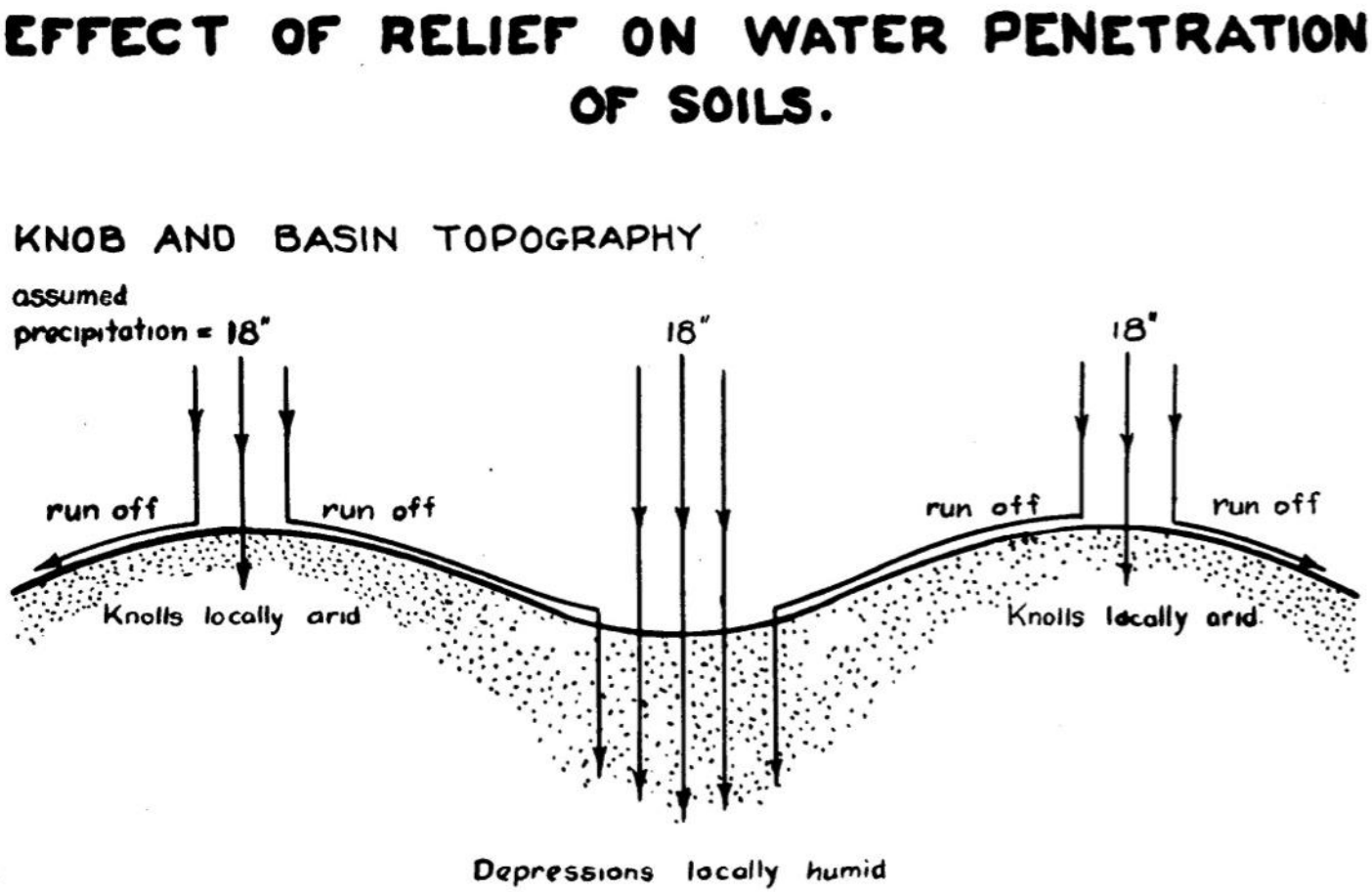


Meso-scale: Topography



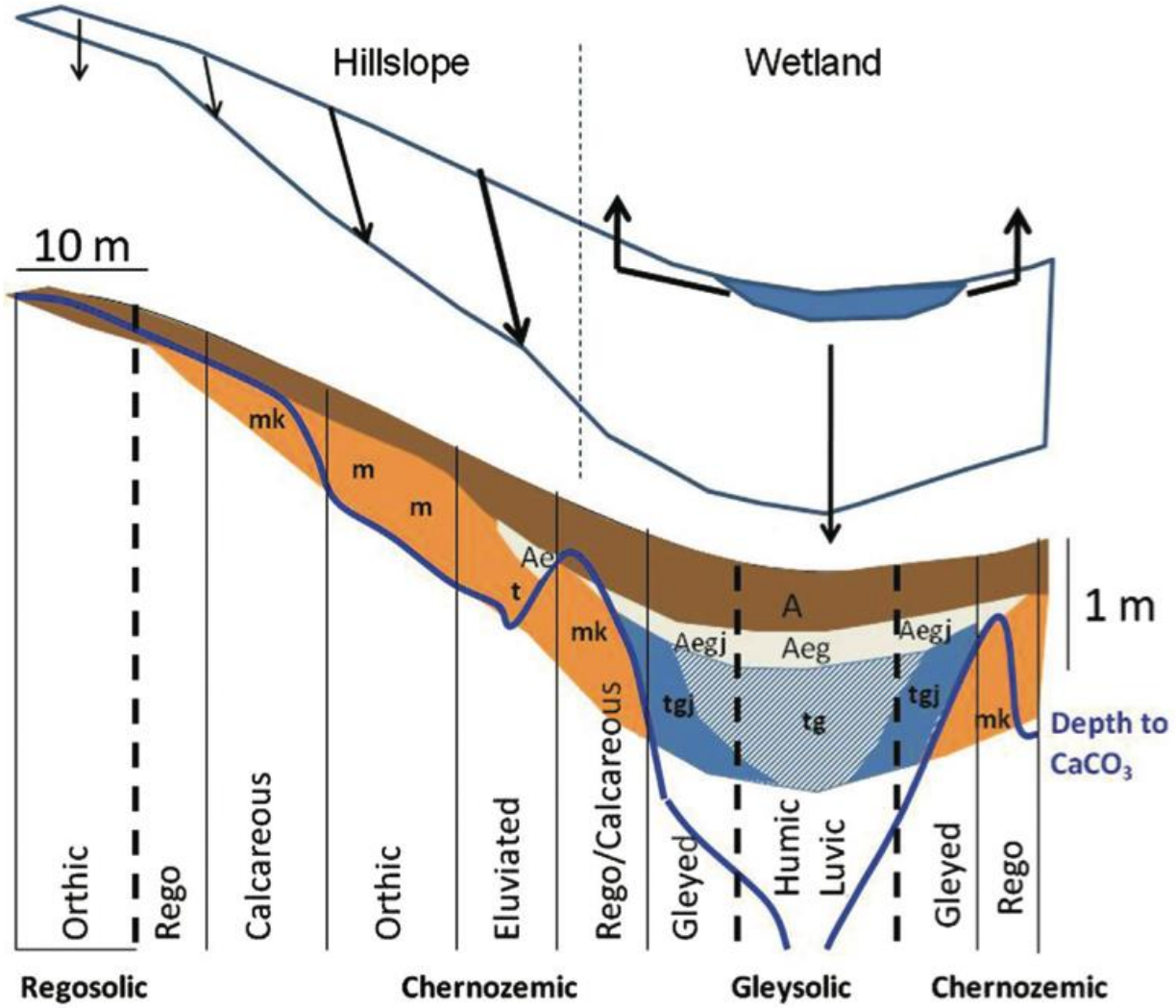
Ellis 1938 Soils of Manitoba

Meso-scale: Topography



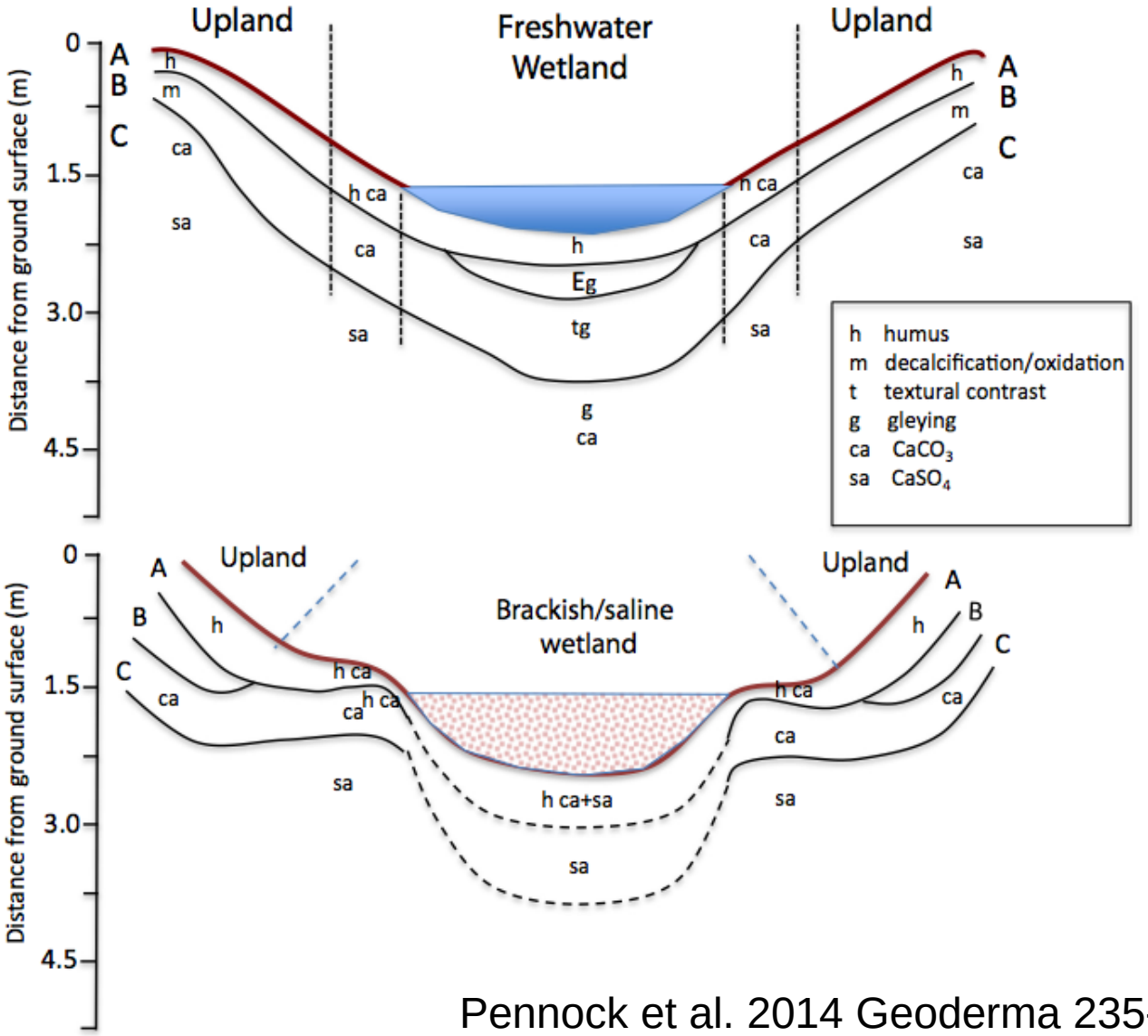
Ellis 1938 Soils of Manitoba

Meso-scale: Catena



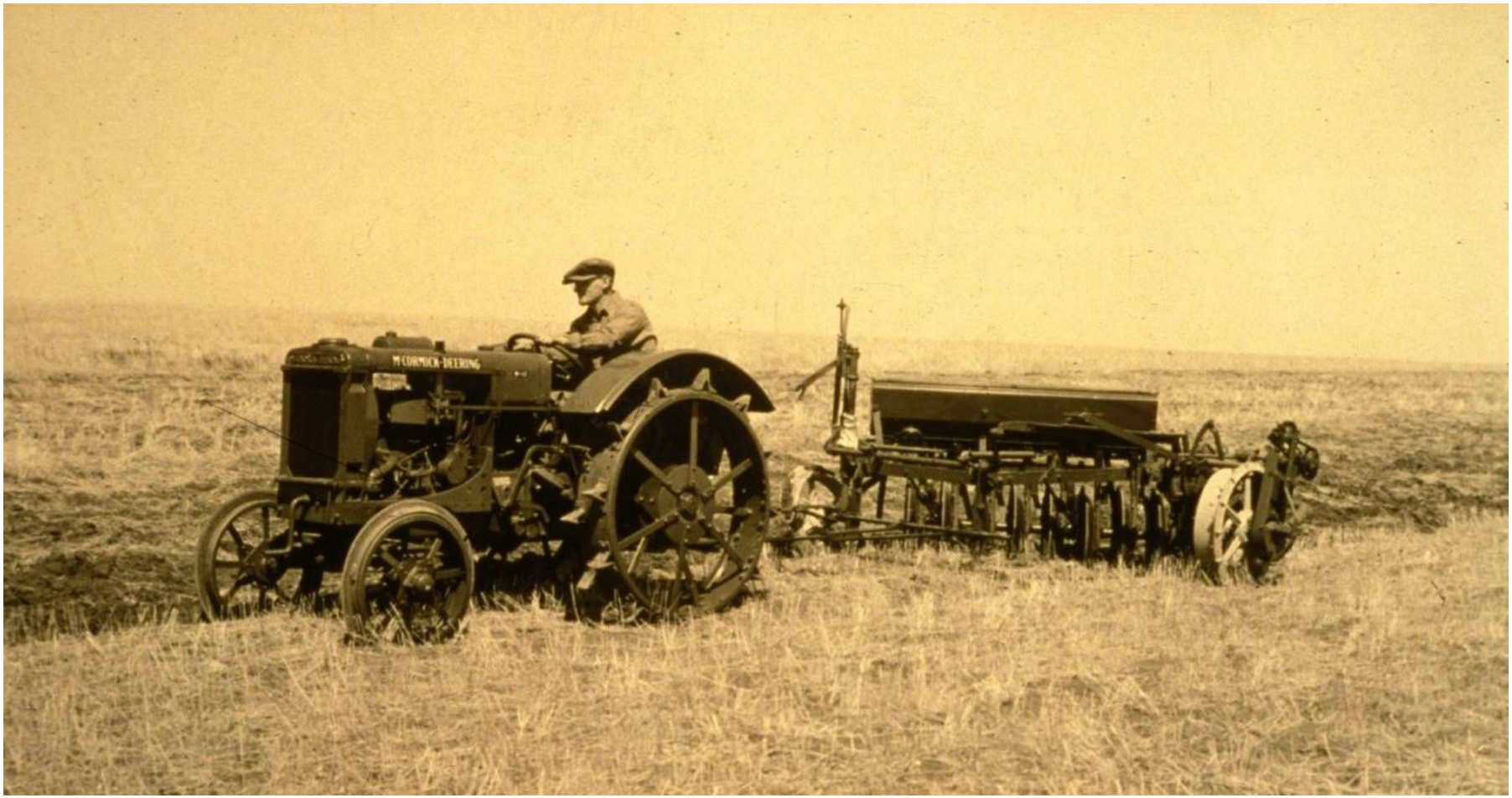
Pennock et al. 2011 CJSS 91: 719-747

Macro- to Meso-scale: Groundwater



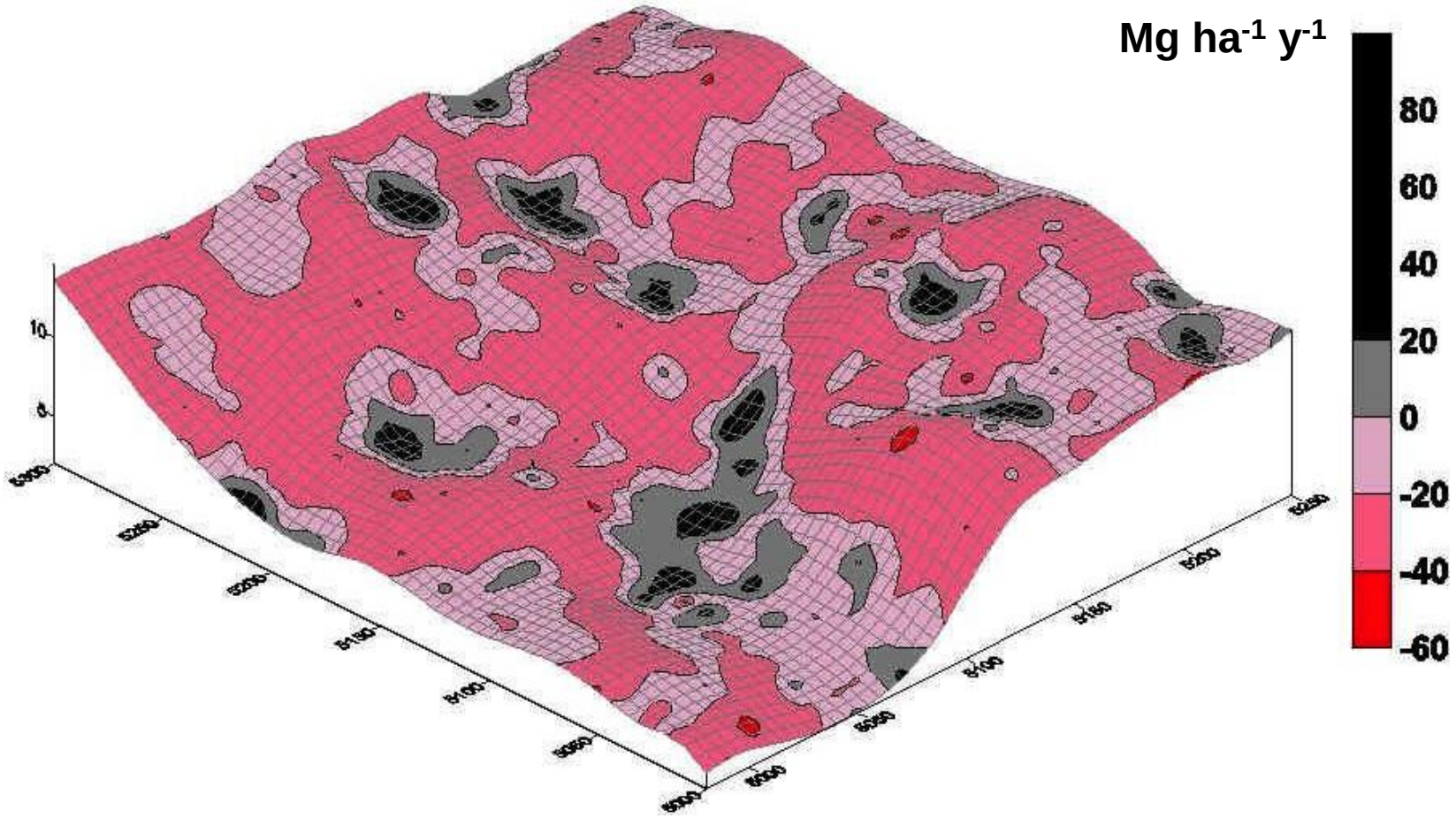
Pennock et al. 2014 Geoderma 235-236: 199-211

The 7th factor: Human activity



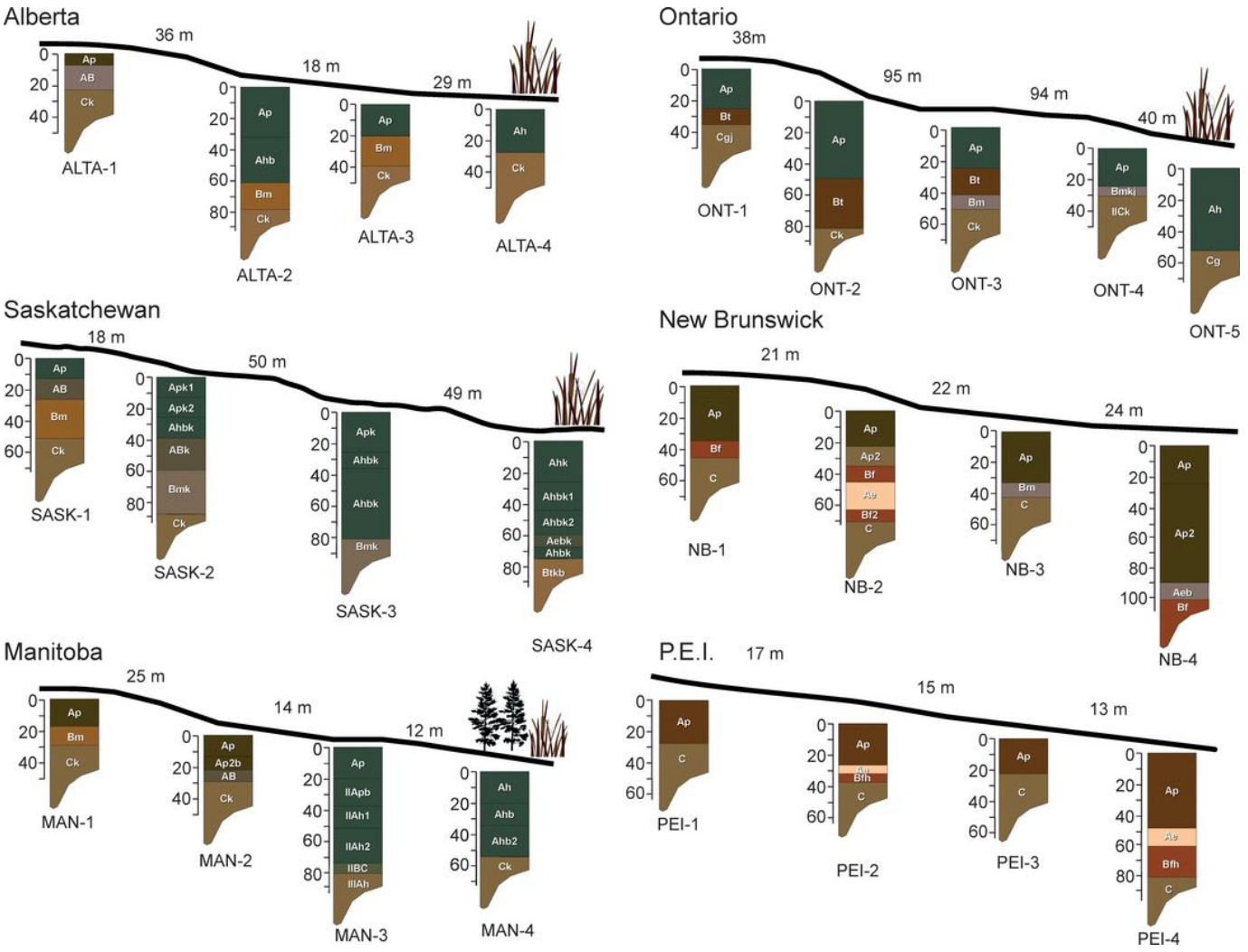
Between- and within-field source of variability

Tillage redistribution: horizontal effects



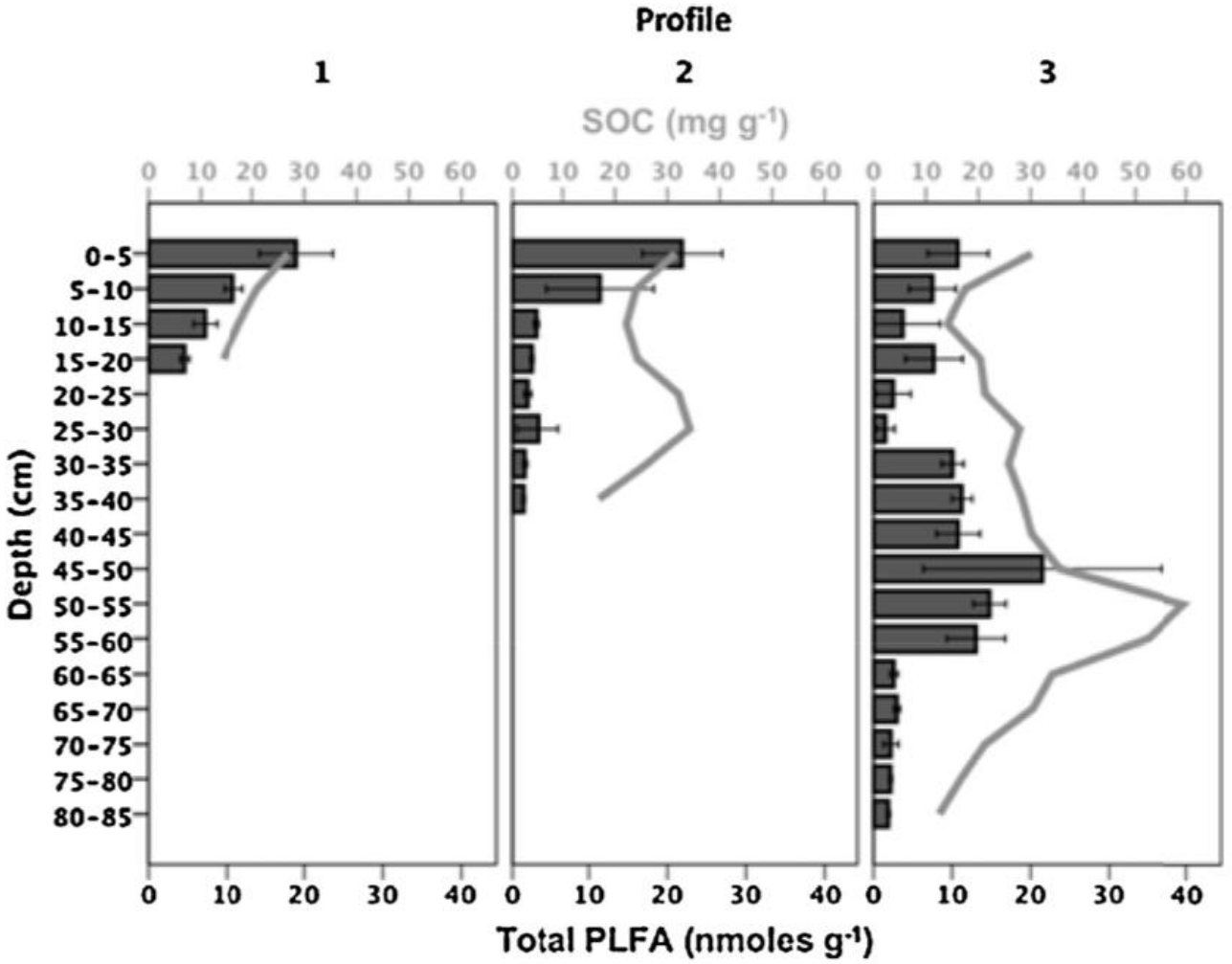
Pennock

Tillage redistribution: vertical effects



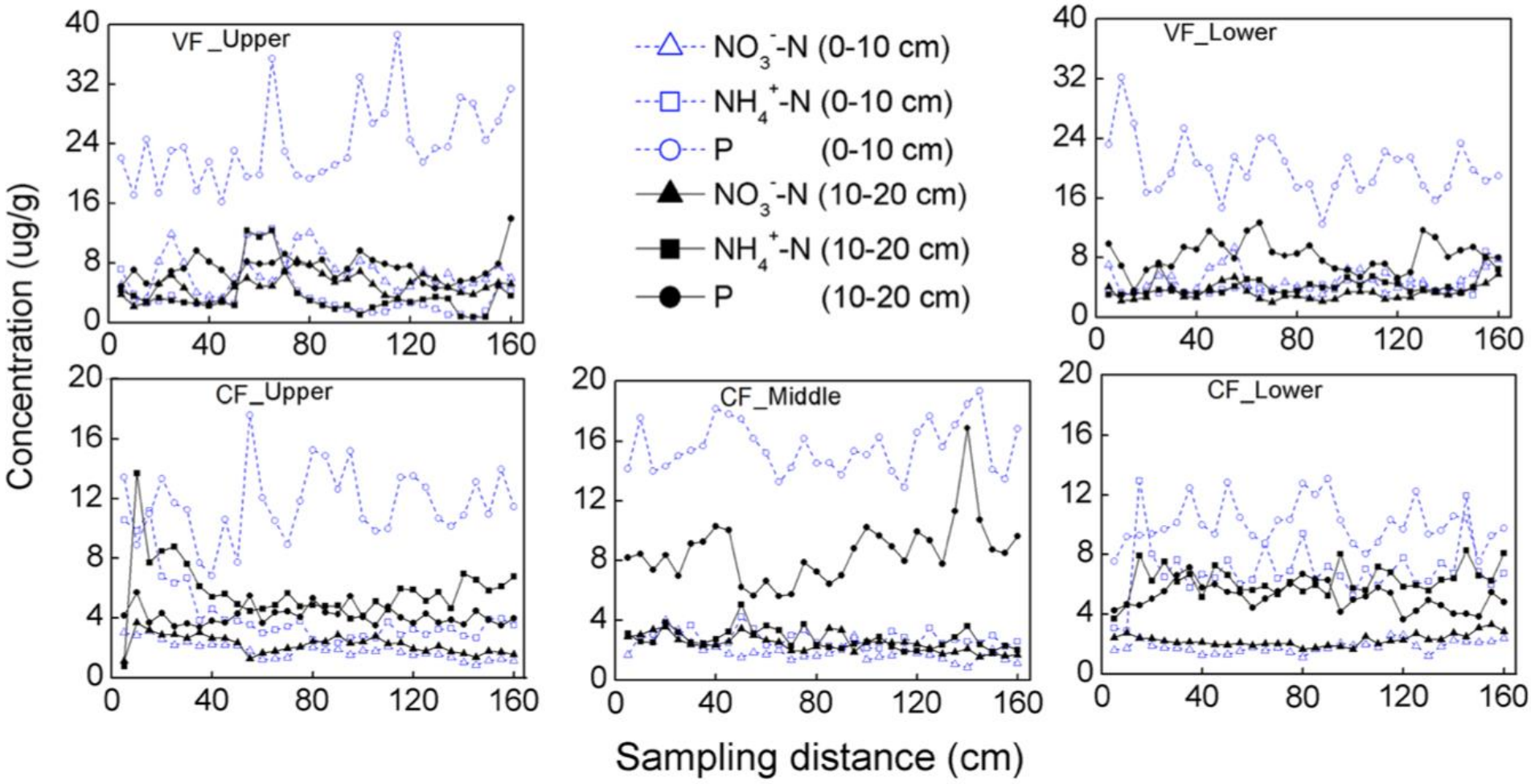
VandenBygaart et al. 2012 Global Change Biology 18: 1441–1452

Tillage redistribution: vertical effects



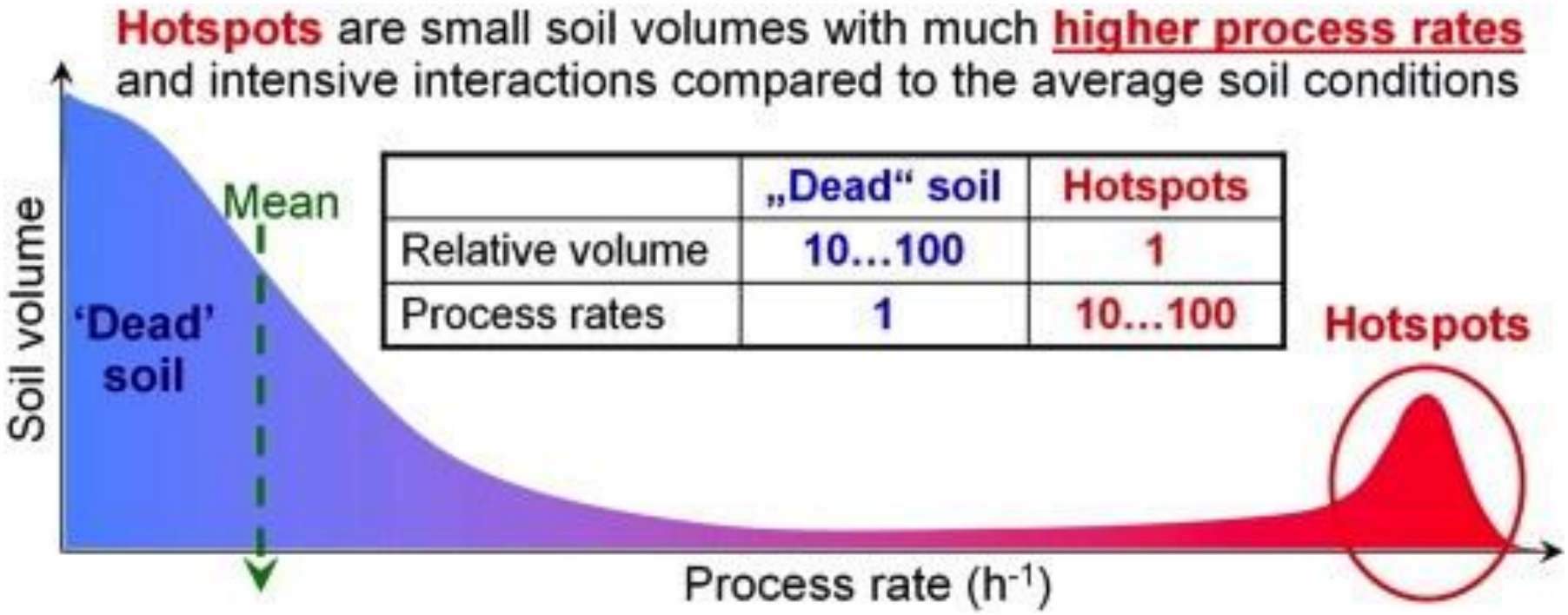
Helgason et al. 2014 Agriculture, Ecosystems and Environment 196: 94–102

No till – still affecting variability!



Hu et al. 2014 Precision Agriculture DOI 10.1007/s11119-014-9384-3

Micro-variability: Hot spots

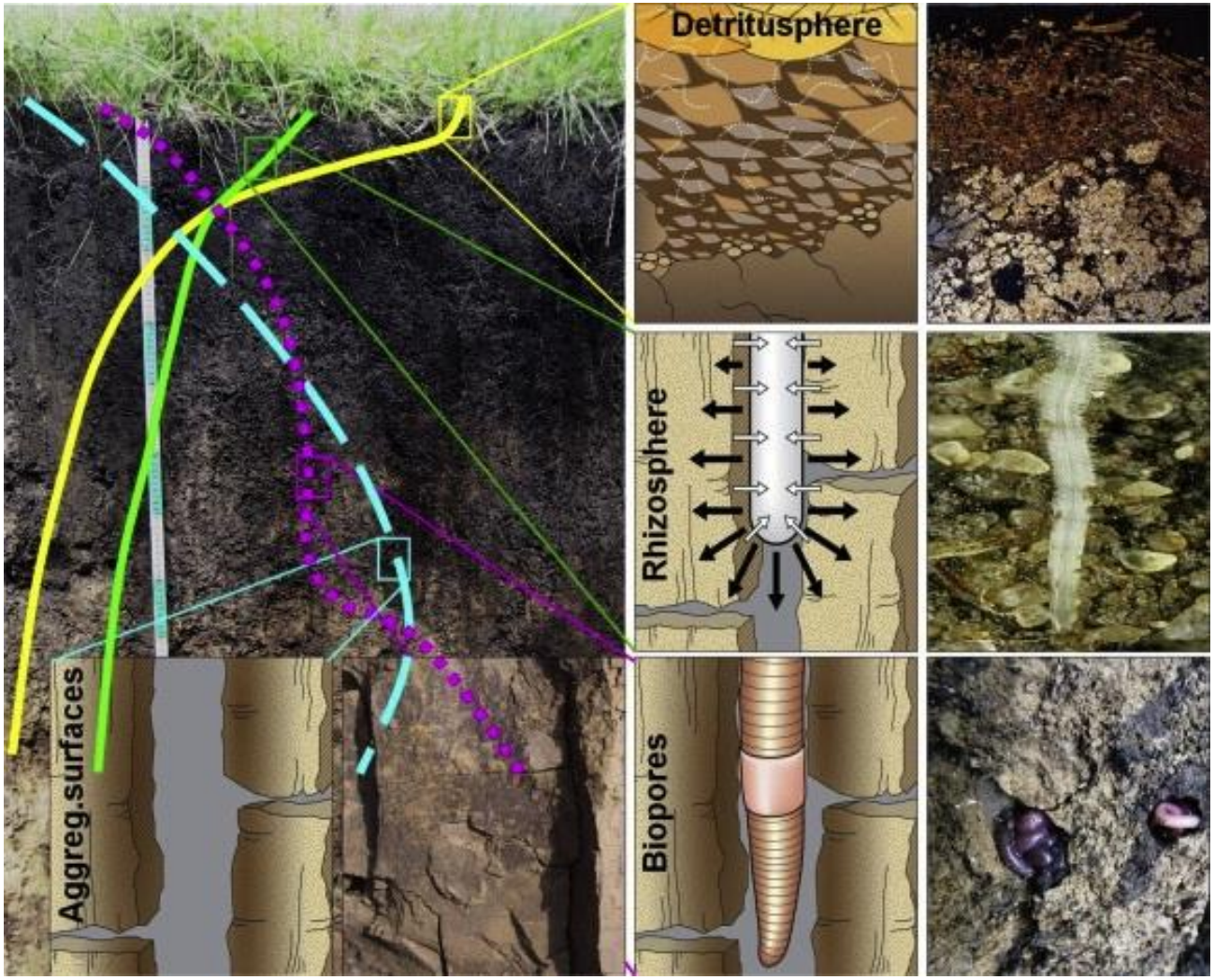


	„Dead“ soil	Hotspots
Relative volume	10…100	1
Process rates	1	10…100

Size of microbial hotspots ranges from a few µm up to several mm.

Kuzyakov and Blagodatskaya 2015 Soil Biology Biochemistry 83: 184-199

Micro-variability: Hot spots



Kuzyakov and Blagodatskaya 2015 Soil Biology Biochemistry 83: 184-199

Temporal variability: Hot moments

Hot moments	Hotspots			
	Rhizosphere	Detritusphere	Biopores	Aggregate surfaces
Biotic				
- Litter fall		XXX	X	X
- Root ingrowth	XXX		XX	X
- Root death	X	XXX	X	
- Animal activities			XXX	
Abiotic				
- Heavy rains		X	XX	XXX
- Snow melting		XXX	X	XX
- Freezing/thawing		XX		X
- Drying/rewetting	X	XX	X	XX
- Erosion events		XX		XX

The number of "X" presents the intensity of the effect: X - small effect, XXX - very strong effect. This assessment was done based on 'expert knowledge'.

Kuzyakov and Blagodatskaya 2015 Soil Biology Biochemistry 83: 184-199

Summary: Multi-scale variability

- The complexity of soil formation has given rise to multi-scale variability of a host of properties
- Horizontally: across the Prairies, across soil zones, across landscapes
- Vertically: due to both natural soil-forming processes and due to soil redistribution
- Temporally: hot moments (hours, days, seasons…)
- New technology is helping us better understand previously-unknown sources of variability